



Socio-technical futures and the governance of innovation processes—An introduction to the special issue

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ABSTRACT

This special issue analyses and reflects on socio-technical futures as core elements in innovation processes and their governance. The special issue assembles twelve contributions that draw on several lines of research mobilizing concepts developed in science and technology studies, such as socio-technical imaginaries and the sociology of expectations, and technology assessment. The papers examine how socio-technical futures are constituted, change and unfold over time, shaped by different practices and in different contexts. Furthermore, they study how different socio-technical futures circulate amongst policy actors and others involved in the governance of innovations, how they shape the governance of innovations and the actual technologies and systems, and how forms of deliberative and reflective future-making can be integrated into policy and innovation processes.

1. Introduction

Socio-technical futures, such as widely debated technological promises, deeply rooted socio-technical imaginaries, or carefully crafted scenarios are important elements in the governance of innovation processes. Generally speaking, by *socio-technical futures* we refer to futures that couple techno-scientific potentials and prospects with envisioned societal change and new social arrangements. Our interest in socio-technical *futures* includes not only the knowledge objects, such as scenarios, roadmaps, imaginaries or narratives, but as well the practices and processes that contribute to the construction of socio-technical futures and the ways they get a bearing on innovation and governance processes.

This special issue takes a practice-oriented perspective on the role of socio-technical futures in innovation governance that explores the concrete manifestations of how expectations, promises and imaginaries are formed and unfold over time, shaped by different practices and in different contexts. The issue studies how socio-technical futures circulate amongst policy actors and others involved in the governance of innovations, how they shape the governance of innovations and the actual technologies and systems, and how forms of deliberative and reflective future-making can be integrated into policy and innovation processes. In this way, the special issue aims to fill an analytic space between more general studies of the performative role of socio-technical futures in science, technology and innovation and approaches that deal with particular anticipatory practices such as foresight and scenario-building as dedicated instruments in the governance of innovation.

The twelve contributions to this issue draw on several lines of research mobilizing concepts developed in science and technology studies and building on our existing knowledge on how socio-technical futures feature in the governance of innovation, ranging from

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sweeping promises around emerging science and technologies to sophisticated foresight processes commissioned by governmental actors.

Promises and hypes of new technologies have been shown to mobilize researchers, industry actors and policy makers to move and invest into emerging technology fields, such as nanotechnology, graphene, synthetic biology or industry 4.0 and to bring about alliances of the most diverse actors from different political and cultural backgrounds (Borup, Brown, Konrad, & Van Lente, 2006; Konrad, Van Lente, Groves, & Selin, 2017; Petersen, 2009). Promises and hypes may also stir public debate on the desirability of what particular technologies might entail for society (Brown, 2003; Kitzinger & Williams, 2005). A closer look, however, often reveals multiple, diverging socio-technical imaginaries that assemble under broad umbrella terms (Rip & Voß, 2013). These imaginaries embody how policy, innovation and societal actors with different experiences and concerns, diverging political priorities and in different cultures frame and envisage how concrete socio-technical futures may unfold, how desirable these might be, and by which forms of governance these could and should be attained (Jasanoff & Kim, 2009; Jasanoff & Kim, 2015).

Implicit or explicit, socio-technical futures are inherently political (Aykut, 2015; Granjou, Walker, & Salazar, 2017). Collective expectations and imaginaries, their explicit claims and implied framings, prestructure which developments are considered relevant and urgent, possible or inevitable. Moreover, the actual possibilities of different actors and social groups to shape and question socio-technical futures and to participate in particular practices of anticipation and assessment differ strongly (Sand, 2019). This being acknowledged more and more, participatory and more inclusive forms have become a growing concern in some strands of futuring, policy-making and innovation processes.

Once certain fields of innovation or socio-technical change have made their way into political and corporate agendas, policy and innovation actors may initiate and participate in various forms of foresight and technology assessment, in order to more systematically scrutinize socio-technical futures, their implications and opportunities for governance (Georgiou, Cassingena Harper, Kennan, Miles, & Popper, 2008). Especially scientists and consultants may also engage in practices of futuring - the active engagement with the future (Hajer & Pelzer, 2018) - providing market forecasts, carrying out foresight processes (e.g. Delphi studies), hype assessments, or developing dynamic models, scenarios or roadmaps. We increasingly see roadmaps of all sorts being used not only within organizations, but to coordinate and mobilize industry-research-policy interaction in innovation governance, be it at the national, sectoral, European or regional level (Carayannis, Grebeniuk, & Meissner, 2016; McDowall, 2012). These roadmaps are used to give structure to newly emerging fields or as a means to open up entrenched socio-technical systems and actor constellations and provide direction for socio-technical change. Socio-technical futures and their underlying assumptions do not need to be explicit though. They may be implicit in visions and imaginaries, in the design of artefacts and systems, the set-up of projects, in forecasts and assessment practices.

As indicated in the examples above, we adopt a broad understanding of *governance of innovation* that focuses on the different modes or institutional rules of coordination among individuals, organizations, societal subsystems and states, ranging from hierarchical steering to networks, communities, associations, and market-like forms of coordination organized by both formal and informal rules (Benz et al., 2007; Treib, Bähr, & Falkner, 2007). Thus, policy - be it science, technology and innovation policy, or policy aiming at socio-technical change in particular policy domains, such as health or energy policy - constitutes only one realm and group of actors contributing to the governance of innovation. Public researchers, private companies, citizens and others are involved in the coordination of innovation processes as well, or aim to actively shape forms of coordination, and hence the modes of governing innovation.

In the context of the governance of innovation processes in democratic societies, social sciences in particular are involved in anticipatory practices. This implies to a certain degree an interventionist understanding of science. The underlying rationale is to make innovation processes more transparent, pluralistic and democratic (cf. Bogusz & Reinhart, 2017; Böhle, 2018). Technology Assessment attached to Parliaments, foresight processes, guidance of informed dialogues, enhancement of engineers' curricula are some of these practices in place.

Furthermore, we see governance not confined to intentional forms of governance, but consider as well forms of de-facto governance (Rip, 2010; Rip, 2006). De-facto governance refers to the patterns and structures of coordination of actions, the definition of problems and ways of approaching them that emerge from the interactions of many actors (Voß & Kemp, 2006, 8–9). Intentional attempts at governance of a multitude of actors feed into de-facto governance, but cannot be reduced to any of those.

In line with such a broad understanding of governance, the *role of socio-technical futures in the governance of innovation* takes different forms. Firstly, a common perspective highlights the performative functions of socio-technical futures that contribute to governance effects, such as mobilization and legitimation, guidance, coordination and sensemaking among innovation and / or policy actors (Konrad et al., 2017). Secondly, some socio-technical futures reflect, explicitly or implicitly, particular understandings of governance and social order, up to envisioning and shaping concrete socio-technical governance arrangements. The former, more implicit forms have been studied in particular as socio-technical imaginaries (Jasanoff & Kim, 2015; Jasanoff, 2015) and visions (Böhle & Bopp, 2014; Grin & Grunwald, 2000; Sand & Schneider, 2017). With policy and administration making ever more intense use of technological systems as governance instruments (Wesseling, Hoppe, & Lemmens, 2015), socio-technical futures anticipating the use and implications of such governance tools are likely to become a more prominent research theme. Thirdly, there are manifold anticipatory practices and procedures, from forecasting, scenario-modelling to foresight and technology assessment that are aimed at creating, assessing and deliberating socio-technical futures. These anticipatory practices can largely be seen as explicit governance instruments, typically targeted at mobilizing the mentioned governance effects. These explicit anticipatory practices are often aimed at policy support (Georgiou et al., 2008; van Est & Brom, 2012), but roadmapping and forms of networked foresight are used among other innovation actors as well (McDowall, 2012; Schubert, Sydow, & Windeler, 2013; van der Duin, Heger, & Schlesinger, 2014). Furthermore, some practices have an anticipatory and governance role, even though they are not set up as dedicated anticipatory

instruments in the first place. These can be scientific review papers that define key features of a field and its prospects (Bitsch & Stermerding, 2013), funding instruments requiring the definition of prospects (Alvial-Palavicino & Konrad, 2018), or prototypes materializing expectations of promising technological paths and designs (Bakker, van Lente, & Meeus, 2012). What becomes apparent here is that there is not only governance *by* socio-technical futures, but also a governance *of* socio-technical futures, that is the different modes, practices, actors and arenas, that constitute socio-technical futures.

2. The contributions to the special issue

Following the presentation of our overarching take on socio-technical futures in innovation governance, we introduce the twelve articles that constitute this special issue. We firstly highlight the main conceptual lines mobilized by the authors, before we present the individual papers in more detail with a focus on how they contribute to our understanding of the empirical role of socio-technical futures in innovation governance.

2.1. Conceptual lenses and contributions

In conceptual terms, several of the articles of this special issue draw on and contribute to our understanding of socio-technical imaginaries, i.e. socio-technical futures that embody collectively imagined forms of social life and social order reflected in the design and fulfillment of scientific or technological projects. This line of research builds on the seminal work of Sheila Jasanoff and colleagues (Jasanoff & Kim, 2009; Jasanoff, 2015). The papers in this issue trace how overarching imaginaries are specified, re-configured and reframed in different geographical, political and actor settings (Cozza, Crevani, Hallin, & Schaeffer, 2019; Karhunmaa, 2018; Levenda, Richter, Miller, & Fisher, 2018; Tarkkala, Helén, & Snell, 2018). In so doing, they corroborate the importance of closely following the locally specific and empirically diverse interpretations of imaginaries and how these become embodied in innovations and their governance (Pfotenhauer & Jasanoff, 2017a, 2017b).

Another group of articles takes inspiration from the sociology of expectations, a field that is concerned with the performative role of expectations in science and technology, and the question how such expectations are shaped and dynamically evolve over time. The articles in this issue contribute in particular to our understanding how different anticipatory practices and the specific assemblages of such practices contribute to the formation of socio-technical futures and their impact on the governance of emerging fields, such as graphene, 3D printing, personalized medicine, and ageing (Alvial-Palavicino & Konrad, 2018; Cozza et al., 2019; Schneider & Lösch, 2018; Tarkkala et al., 2018). Furthermore, the concept of governance of and by expectations (Konrad & Alvial Palavicino, 2017; Konrad, 2010) has been used in a number of articles to capture the interplay of the different modes of how expectations are shaped and governed and how these feed into different modes of governing innovation (Beumer & Edelenbosch, 2019; Hielscher & Kivimaa, 2018; Tarkkala et al., 2018).

Next to the articles building predominantly on analytical perspectives on the role of socio-technical futures in the governance of innovation, two of the contributions draw on the rich literature on technology assessment that aims at intervening in the making and the societal and political deliberation of socio-technical futures (Stermerding, Betten, Rerimassie, Robaey, & Kupper, 2018; Weber, Gudowsky, & Aichholzer, 2018).

2.2. The construction and deconstruction of socio-technical futures

The first set of articles investigates how particular socio-technical futures have emerged and are socially constructed by different groups, organizations and arenas involved in innovation and governance.

Egbert and Paul scrutinize a new type of border and access control technology developed under the aegis of the US Department of Homeland Security in the US (Egbert & Paul, 2018). The vision is to be able to quickly and objectively screen individuals for malintent, especially for terrorist intentions, in a walkthrough procedure (e.g. at airports or train stations) focusing on real-time physiological cues and behavior patterns. This type of risk governance technology illustrates a paradigm shift of the National Security Strategy after 9/11 and its related socio-technical imaginaries centered around the concept of preemption assuming a radically risky and uncertain future society with ubiquitous terrorist threats. The analysis shows how this collectively shared vision of security authorities governs the development of the technology and how this vision is being inscribed in technology.

Cozza et al. study how future ageing is constructed by different actors, such as companies, public sector organizations and research-oriented actors engaged in the governance and innovation of welfare technologies (Cozza et al., 2019). Their analysis is based on an ethnographic study conducted during a trade show in Sweden where these actors regularly meet. They make us aware of the differences in how the future elderly are constructed by these actors, just as to commonalities, such as a general agreement in associating future ageing with an ever-increasing consumption of technology. Moreover, they point out blind spots, i.e. to issues and actor groups which have not been taken into account. Significantly, the increased ethical and cultural diversity of Sweden and gender differences have not been considered. Furthermore, the voices of many relevant professions and the elderly themselves and their relatives were missing. This type of analysis of sociotechnical futures, in a way combining reconstruction and deconstruction, is very useful as it allows to increase the complexity of socio-technical futures and the plurality of perspectives, which in turn should help to govern long-term innovation processes of this kind. In this respect, Cozza et al. raise a similar plea as Beumer & Edelenbosch (see below) hinting to actor groups not represented in a given socio-technical futures.

While welfare technologies for the elderly have been discussed for some time, Meyer draws our attention to the early phases when powerful guiding visions are still emerging (Meyer, 2019). Conceptually, he links organization studies, in particular the theory of

sensemaking, with insights from science and technology studies on socio-technical futures, in order to develop an understanding of the processes and conditions that allow certain envisioned futures to emerge and become widely accepted, with a focus on the role of organizations in this process. These conceptual considerations are illustrated with a study of the impressive ascendancy of ‘Industrie 4.0’ in Germany from its initial presentation in 2011, building on a rich dataset of interviews across a variety of German companies and other organizations. He concludes with a reflection on the governance role of such envisioned futures. While such envisioned futures are a rather poor governance tool for more specific attempts at steering the development, they can be seen as a powerful form of indirect – or in the terms of this special issue – de-facto governance mechanism.

2.3. *Varieties of futures in energy and health policy*

The second group of papers studies the development of socio-technical futures with a specific interest in how these futures are reconfigured and / or maintained, either over time or when being translated across levels of governance. The malleability, the interpretative flexibility and the non-deterministic nature of socio-technical futures in the context of governance and policy practices is a key theme here. All studies of this section address socio-technical futures that reason from the perspective of established policy domains. A general transformation of the energy system and the health system respectively is on the political agenda. This means that a considerable number of innovations are involved in such a transformation of which some are highlighted and ascribed particular importance in the governance of the transformation (e.g. smart meters in the change of the energy system).

Tarkkala *et al.* provide a longitudinal study of the dynamics of the sociotechnical imaginary of „personalized medicine“ in Finland from 2005 to 2015 (Tarkkala *et al.*, 2018). In Finland the promotion of personalized medicine is an intensely state-driven and national endeavor. The authors use policy framing analysis as a means to follow how both the rhetoric of promise and the suggested practical measures to realize the promise have shifted over time. They interpret these shifts as a form of maintenance that simultaneously pursues and reconfigures the imaginary of personalized medicine. While the imaginary is maintained as a label for the potential of contemporary biomedicine, its content and meaning has changed along with key governance actors. Today, the envisioned future is less about better health services for citizens and more about economic prospects related to health technologies and data driven medicine.

Hielscher and Kivimaa study the role of UK policy in the governance of and by expectations for the case of smart meters (Hielscher & Kivimaa, 2018). As Tarkkala *et al.*, they take a longitudinal perspective following expectations over time. The authors show how policy has used expectations for legitimizing smart meters as a form of governance by expectations and at the same time has engaged in the governance of these expectations stabilizing expectations over time, by linking smart meter expectations to shifting energy policy goals and visions, different technological promises and developing persistent narratives around smart meters. In so doing, Hielscher and Kivimaa highlight the relevance of expectations as an element of governance throughout policy design and implementation, beyond early phases of development, and the role of policy as enactors, rather than selectors of technological expectations.

Karhunmaa shares with Hielscher and Kivimaa the focus on socio-technical futures manifest in energy policy and the interest in stability and change, respectively differences, in energy futures (Karhunmaa, 2018). She studies socio-technical imaginaries in Finnish energy policy as well as the suggested policies to achieve them, comparing policy debates at the national and the local level. Karhunmaa shows that the overarching socio-technical imaginary of carbon neutrality is shared across levels, whereas very different ideas prevail regarding the types of policy appropriate to achieve them. At the national level, predictability and stability of policies serve as the guiding ‘governance imaginary’. In contrast, at the local level of city governance, flexible and adaptable policy measures have been suggested. Thus, in line with Egbert and Paul, Karhunmaa sharpens our attention for the explicitly envisaged forms of governance as an element of socio-technical futures and the temporalities inherent to these imaginaries of governance.

As Karhunmaa, Levenda *et al.* address socio-technical energy futures from a multilevel governance perspective. They analyze and compare the development of two energy innovations, namely smart grids and distributed solar generation in two United States regions (the Pacific Northwest and the Desert Southwest) and two metropolitan areas within those regions (Portland, Oregon, and Phoenix, Arizona) (Levenda *et al.*, 2018). They provide evidence that national sociotechnical imaginaries diverge at the regional and local level leading to specific imaginaries at each level. In the governance of energy innovations, local and regional socio-technical imaginaries both refract and reflect overarching national imaginaries. Even largely undisputed energy values such as reliability, stability, democracy, and independence that shape energy innovations do so in sharply different ways. The same shared values lead to different innovation strategies and policies at different levels due to the particular historical, institutional, infrastructural, cultural, and political-economic contexts in place.

2.4. *Anticipatory practices and modes of innovation*

A third set of articles takes a practice-based perspective that pays attention to the context and the means by which sociotechnical futures and inherent expectations are created, circulated and shared, and the different material and institutional settings in which such practices take place. They investigate how anticipatory practices in a particular field as FabLabs or graphene emerged and changed over time as part of specific arrays or assemblages of practices, actors, organizations, and material elements, and how these assemblages of practices shape simultaneously socio-technical futures and the governance within these fields. Both articles understand anticipatory practices not only as explicit anticipatory practices but also as de-facto anticipatory practices, for instance in the form of technical objects or a Nobel Prize, that are not primarily conducted as *anticipatory* practices, but nevertheless have anticipatory qualities.

Alvial-Palavicino and Konrad follow the anticipatory practices that constituted different arenas relating to scientific, policy and market actors where expectations on graphene have been voiced, spread and assessed (*Alvial-Palavicino & Konrad, 2018*). They show how different practices as the circulation of promises in high-profile journals, roadmapping and calculative practices of consultancies have contributed to the formation of particular socio-technical futures for graphene and their role in the creation of what has been considered a graphene hype. Furthermore, they reflect on the specific forms of performativity that different practices create and how these practices have contributed to the emergent and evolving governance of the graphene field.

Schneider and Lösch share the interest in a perspective on socio-technical futures that highlights the practical and material basis of future-making, rather than remaining at the level of representations of futures (*Schneider & Lösch, 2018*). Their case is about digital manufacturing (including 3D printing). They study how the FabLab assemblage of actors, organizations, objects, practices and visions has opened up from a predominantly elitist circle of scientists and technological basis to an assemblage characterized by grassroots labs, widely accessible tools and objects. This opening up of the FabLab assemblage led to a more distributed governance of the field and the innovation processes in that field. Schneider and Lösch conclude that future-making and the governance of socio-technical innovation can be democratized if the means to make and explore futures are themselves democratized. This corroborates the importance of integrating the analysis of technology governance and socio-technical imaginaries.

2.5. Technology assessment deliberately shaping socio-technical futures

The fourth and last set of papers describes and reflects on the engagement of researchers in science and technology studies and technology assessment institutions in the making and refinement of socio-technical imaginaries as part of their practice at the interface of science, policy and public. The intention of these interventions is aimed at supporting an informed debate about socio-technical futures around emerging technologies. A major concern is the search for suited practices and arrangements that allow these practices to have a real impact on the governance of the innovations at stake.

Stemerding et al. deal with the making of synthetic biology futures in the light of responsible research and innovation (*Stemerding et al., 2018*). The current practices of future making are characterized by a lack of activities supporting anticipation, inclusion, reflexivity and responsiveness, and a divide between engineers and scientists with knowledge about technological options on one side, and civil society actors with knowledge about social issues and concerns on the other side. The authors report on different future-making activities they designed and conducted with students of Synthetic Biology, researchers, societal stakeholders and policy makers. These activities partly followed a technology options-oriented mode encouraging students to reflect on application scenarios and moral implications of their work, and partly a societal objectives-oriented mode of future making. Stemerding et al. discuss the actual achievements in terms of responsible research and innovation and close with a plea to create continuous, joint spaces and processes (arenas) in which innovators and societal actors are invited to critically examine both societal needs and opportunities to innovation.

Similar to Stemerding et al., *Beumer and Edelenbosch* are in search of ways to support an informed societal debate about expectations on emerging technologies, allowing different stakeholders to develop ‘societally robust’ expectations that are informed not only by their own knowledge, but by a consideration of the perspectives of other stakeholders as well (*Beumer & Edelenbosch, 2019*). However, when engaging in the field of hybrid potato breeding, a radically new food technology, Beumer and Edelenbosch encountered resistance by stakeholders to engage in time-consuming collective anticipatory practices as scenario workshops and the like. Against this backdrop, they suggest a tool for mapping expectations that captures and compares core assumptions underlying the expectations of different stakeholders. In this way, they reveal both differences and commonalities in the concerns and assumptions of stakeholders that were not apparent before. Such a mapping exercise may then serve as an indirect way of creating awareness for the different perspectives and expectations of stakeholders, or might also serve as a starting point for more direct forms of dialogue among stakeholders.

Weber et al. are dealing with the introduction of technology assessment and foresight practices at the Austrian parliament, where such an approach had so far been absent (*Weber et al., 2018*). The pilot project tested a specific methodology with the case of Industry 4.0. The methodology comprised a mix of scientific analysis, interactive workshops, and discussion formats. It offered thus various kinds of policy learning. Besides presenting some of the results on identified policy challenges related to Industry 4.0, the authors reflect on achievements and limitations of introducing these for the Austrian parliamentary context rather unusual forms of deliberation. Parliamentarians clearly signaled the need for a continuation of this type of parliament-focused anticipatory practice. It became, however, also apparent that the more open forms of dialogue across political parties pose a challenge for the Austrian political culture. The authors conclude that topics requiring forward-looking and long-term planning may be most appropriate, as these are seldom addressed in the daily work of Parliament and thus also provide protected spaces allowing parliamentarians to engage openly in debates.

3. Concluding remarks

With this special issue we intend to shed light on the breadth of ways how socio-technical futures feature in the governance of innovation, from newly emerging technologies and imaginaries to transformations of established socio-technical systems and futures, and from the debate in policy circles to wider communities contributing to innovation governance. Moreover, we hope to have provided the reader with an overview of conceptual lenses and the aspects these highlight, reaching from a focus on the content of futures in socio-technical imaginaries to more practice and process-oriented perspectives.

In so doing, it became clear that the performativity of socio-technical imaginaries needs to be considered when studying the

governance of innovation and transformation processes. Moreover, it is important to understand the more or less explicit pre-figuration of modes of technology governance inherent in socio-technical futures. Furthermore, approaches based on theories of practices allow to study dedicated anticipatory practices and arrangements as well as other social practices as de-facto forms of governance shaping innovation processes.

The present special issue is the result of an open call distributed in late 2016 generating about 50 submissions. The twelve papers published in this issue are the result of a thorough selection process consisting of a first round of preselection by the editors and multiple rounds of peer review.

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